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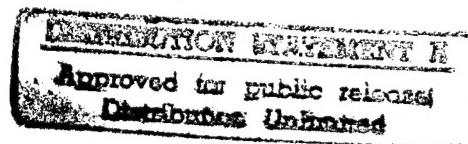
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UNITED STATES ATOMIC ENERGY COMMISSION

SERIAL REPORTS ON START-UP EXPERIMENTS.
NO. 4. THE SIMULATED BAROMETRIC
COEFFICIENT

By
Jack Chernick

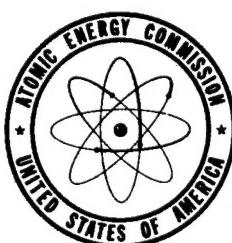


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Brookhaven National Laboratory
Upton, New York

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SERIAL REPORTS ON START-UP EXPERIMENTS

74. The Simulated Barometric Coefficient

By Jack Chermick

February 15, 1951

Introduction

The barometric coefficient of a reactor has been determined in the past by following the change in reactivity due to variation in atmospheric pressure. These changes are normally small and it has therefore been difficult to obtain an accurate measurement of the barometric coefficient. For this reason, it was decided to use the reactor fans to simulate the barometric effect. By sealing the inlet air ducts and operating one or more fans a uniform pressure drop ranging from 15 to 53 mm Hg could be maintained over the reactor. These pressure changes are much greater than would be provided by the most severe weather conditions.

Results of the Experiment

The results of the experiment are given in the following table which shows the critical rod positions under the different pressure conditions, and the reactivity changes involved,

TABLE I

| <u>Barometric Coefficient of BNL Reactor</u> | | | | |
|--|-----------------------|----------------------------|----------------------------|------------------------------------|
| Critical Rod Position (cm) | Pressure Drop (mm Hg) | Change in Pressure (mm Hg) | Change in Reactivity (inh) | Barometric Coefficient (inh/mm Hg) |
| 425.2 | 0 | | | |
| 445.5 | 15.4 | 15.4 | 5.6 | 0.36 |
| 470.8 | 38.3 | 22.9 | 7.0 | 0.31 |
| 490.7 | 53.2 | 14.9 | 5.5 | 0.37 |
| 419.8 | 0 | 53.2 | 19.7 | 0.37 |

The average value obtained is thus 0.35 ± 0.014 inh/mm Hg. The internal measure of precision does not reflect the actual accuracy of the experiment.

The sensitivity of the #9 control rod in the region from 425 to 490 cm is very close to constant as can be seen from Fig. 7 of C-4513, the second report of this series. Its value could be checked from data obtained in the present experiment. We get 0.278 ± 0.012 inh/cm which is in good agreement with previous data. The error introduced by the uncertainty in the rod calibration is thus about 4%. A possibly more serious source of error is indicated by the fact that the final critical position of the #9 control rod differs from its initial position. The loss of reactivity involved is 1.5 inh out of a total change of about 19 inh. The possible error involved is 8%. An increase of 1°C in the overall reactor temperature could account for the discrepancy.

We therefore estimate the barometric coefficient of the BNL reactor at 0.35 ± 0.03 inh/mm Hg. The error estimate is probably conservative. This value is undoubtedly the most accurate yet obtained in reactor work. If there exists a residual effect due to the diffusion of nitrogen through relatively inaccessible graphite pores, it is small and does not show up at the pressure differences involved in these experiments.

Experimental Details

The simulated barometer experiment took place on the night of August 31, 1950 at a loading of 417 channels. The loading pattern was the same as that used in the hot rod experiment (Fig. 4, C-4413), with two central channels vacant for Newson hole evaluation. The inlet air ducts were sealed prior to the experimental run with wooden 4 x 4 boards covered with plywood and tarpaulin. From one to three fans were turned

on during the experiment which ran from 19:15 EST to 22:05. There was little change in atmospheric pressure during the run. The following accurate pressure data were taken at the Meteorology station on August 31.

| <u>Time (EST)</u> | <u>Atmospheric Pressure (mm Hg)</u> |
|-------------------|-------------------------------------|
| 16:30 | 759.13 |
| 19:30 | 759.08 |
| 22:30 | 758.57 |

Reactor temperatures were not read and, as already noted, may account for the small loss in reactivity observed at the end of the experimental run.

The reactor was started up at 19:15 EST with all rods out and levelled off at virtually zero power with the #9 control rod. The first fan was turned on at 19:52. Subsequent events are shown graphically in Figs. 1 to 3 which give the neutron counting rate against time, the reactor periods corresponding to the different settings of the #9 control rod and the pressure drop across the reactor. Some of the difficulties encountered during the experiment are likewise shown in those graphs. Thus a second fan was turned on at 20:28 but failed to operate. Again there was some difficulty in finding the exact critical position with two fans in operation. The reason for this difficulty is apparent from Table II which shows that the reactor pressure was gradually decreasing during this time. The reactor pressures were measured in both the north and south plenum chambers with mercury manometers and at the gap with a more accurate micromanometer. The data, tabulated in Table II, show that there was little, if any, pressure gradient over the reactor. The final times shown in this table should not be taken literally as there was some trouble with the clock. The pressure jumps are however readily correlated with the data shown in Figs. 1 to 3.

TABLE II

Reactor Pressure Drop (mm Hg)

| <u>Time (EST)</u> | <u>South Plenum</u> | <u>North Plenum</u> | <u>Gap</u> |
|-------------------|---------------------|---------------------|------------|
| 19:50 | 0 | 1 | 0 |
| 19:55 | 13 | 13 | 13.5 |
| 20:00 | 15 | 15 | 16.4 |
| 20:05 | 15 | 15 | 15.8 |
| 20:10 | 15 | 15 | 15.8 |
| 20:15 | 15 | 15 | 15.8 |
| 20:20 | 15 | 15 | 15.8 |
| 20:25 | 15 | 15 | 15.8 |
| 20:30 | 14 | 15 | 15.8 |
| 20:35 | 19 | 14 | 14.7 |
| 20:40 | -- | 13 | 12.9 |
| 20:45 | 37 | 35 | 37.7 |
| 20:50 | 37 | 37 | 37.8 |
| 20:55 | 37 | 37 | 37.8 |
| 21:00 | 37 | 38 | 38.3 |
| 21:05 | 38 | 38 | 38.3 |
| 21:10 | 38 | 38 | 38.5 |
| 21:15 | 51 | 51 | 51.9 |
| 21:20 | 53 | 53 | 53.1 |
| 21:25 | 53 | 53 | ---- |
| 21:30 | 53 | 53 | 53.1 |
| 21:35 | 53 | 53 | 53.1 |
| 21:40 | 53 | 53 | 53.3 |
| 21:45 | 53 | 53 | 53.3 |
| 21:50 | 53 | 53 | 53.3 |
| 21:55 | 53 | 53 | 53.3 |
| 22:00 | 2 | 2 | 0.1 |

Reduction of Experimental Data

The reactor periods shown in Figs. 1 to 3 were obtained graphically rather than by more objective numerical methods. This method is used as a time-saving device in view of the large amount of experimental data collected and the limited manpower available. Reactor periods were converted to inhours of reactivity by means of the Hughes formula;

$$\text{inh} = \frac{54}{\tau} + \frac{20.3}{\tau + 0.62} + \frac{204}{\tau + 2.19} + \frac{535}{\tau + 6.5} + \frac{2036}{\tau + 31.7} + \frac{787}{\tau + 80.3}$$

We have consistently used the Hughes formula for this conversion. However, the formula may require modification on the basis of BNL subcritical experiments which have not yet been analyzed. It should be noted that refinement of the formula may necessitate the appropriate modification of temperature and barometric coefficients, etc.

In Table III, we have listed the data required to evaluate the simulated barometric coefficient of the reactor. Critical rod positions (Table I) were obtained from these data by interpolation. In addition, the sensitivity of the #9 control rod could be obtained from the reactivity changes associated with rod movements at approximately constant reactor pressure. Since the rod sensitivity is maximal at about 440 cm, the sensitivity curve is quite flat in the 420 - 490 cm range. By lumping all the pertinent data together we obtain a value of $0.278 \pm 0.012 \text{ inh/cm}$ for the rod sensitivity in this range. As has been noted, this value is in good agreement with previous calibration data.

TABLE III
Reduction of Experimental Data

| Time Interval (EST) | #9 Rod Position (cm) | Pressure Drop (mm Hg) | Reactor Period (sec) | Reactivity (inh) |
|---------------------|----------------------|-----------------------|----------------------|------------------|
| 19:15 - 18 | 0 | 0 | 67.4 | 37.1 |
| 19:19 - 25 | 420.13 | | 3,070 | 1.17 |
| 19:25 - 37 | 427.04 | | -6,390 | - 0.57 |
| 19:37 - 48 | 425.50 | | -40,000 | - 0.09 |
| 19:48 - 50 | 450.04 | ↓ | -540 | - 7.24 |
| 19:53 - 56 | 425.50 | 13.5 | 775 | 4.48 |
| 19:56 - 20:01 | 450.03 | 15.4 | -2,700 | - 1.36 |
| 20:01 - 05 | 443.02 | | 4,300 | 0.83 |
| 20:05 - 15 | 446.03 | | -12,600 | - 0.29 |
| 20:15 - 20 | 445.52 | | -30,000 | - 0.12 |
| 20:20 - 22 | 551 | | -148 | -34.8 |
| 20:22 - 33 | 445.53 | ↓ | 40,000 | 0.09 |
| 20:42 - 48 | 445.53 | 37 | 533 | 6.40 |
| 20:55 - 21:00 | 467.53 | 38 | 4,800 | 0.75 |
| 21:05 - 09 | 471.51 | 38.3 | -17,000 | - 0.19 |
| 21:09 - 13 | 550 | ↓ | -234 | -18.7 |
| 21:15 - 20 | 471.00 | 51.5 | 830 | 4.20 |
| 21:20 - 23 | 571 | 53.2 | -250 | -17.3 |
| 21:23 - 29 | 471.02 | | 790 | 4.41 |
| 21:29 - 41 | 490.00 | | 20,000 | 0.18 |
| 21:41 - 46 | 426.02 | | -2,280 | - 1.62 |
| 21:46 - 22:05 | 419.01 | ↓ | 16,000 | 0.23 |

SIMULATED BAROMETER EXPERIMENT
NEUTRON COUNTING RATE VS TIME

AUG. 31, 1950
LOADING: 417 CHANNELS

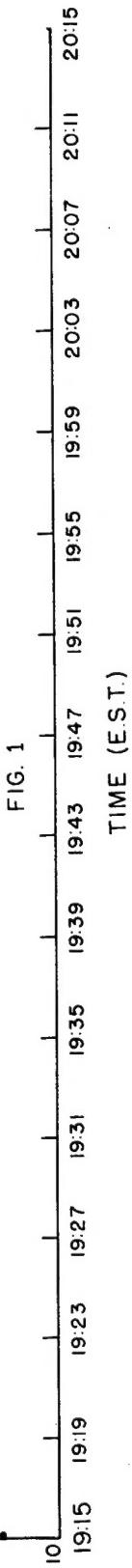
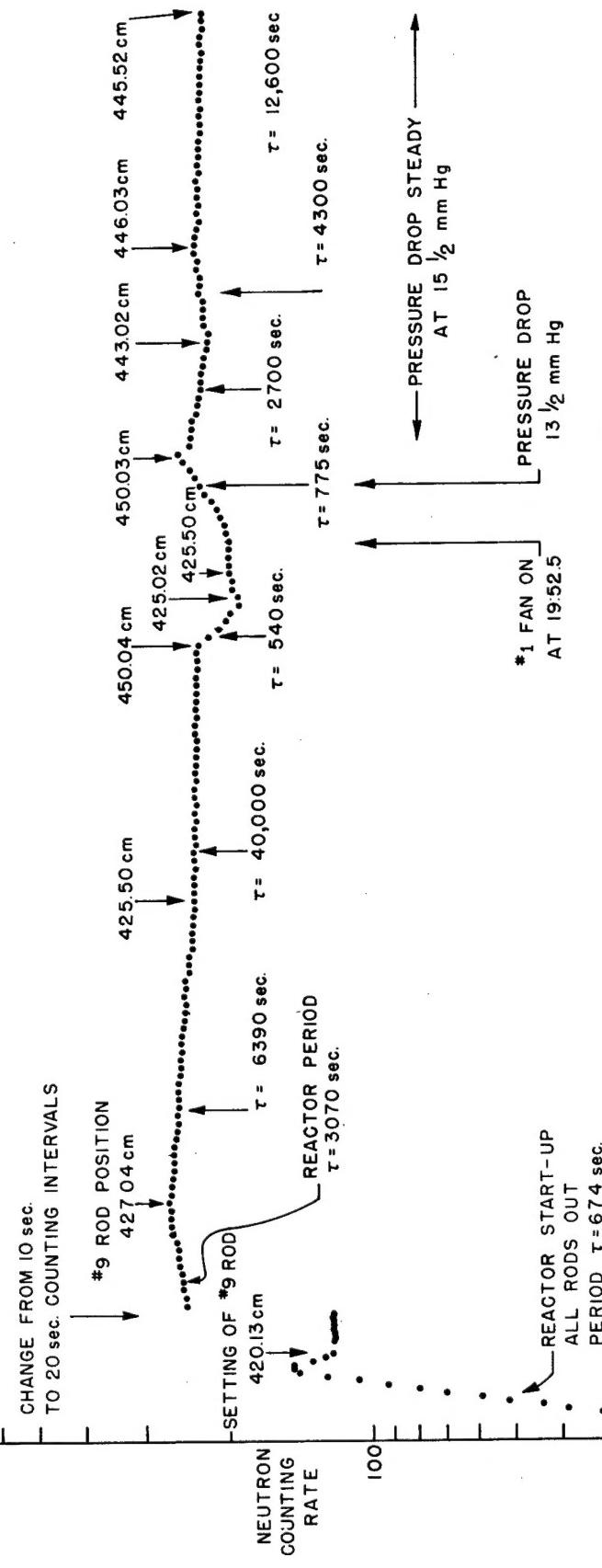
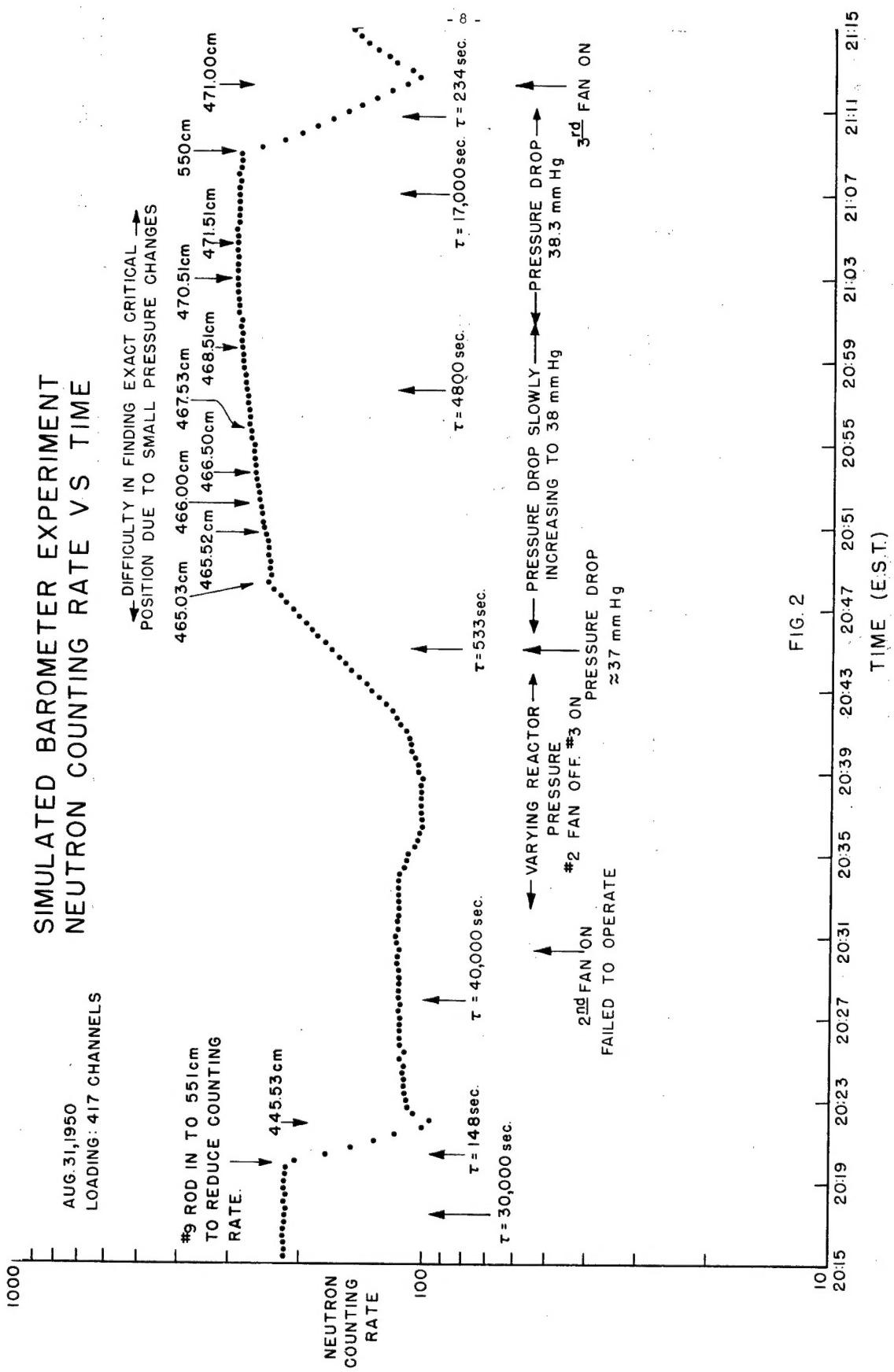


FIG. 1



SIMULATED BAROMETER EXPERIMENT
NEUTRON COUNTING RATE VS TIME.

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